EXAMPLE 5

The material used was SUJ2 as in Comparative Example 2. Heating at 845° C. for hardening was followed by oil quenching and then by tempering at 350° C.

EXAMPLE 6

The material used was SUJ2 as in Comparative Example 2. Heating at 845° C. for hardening was followed by oil quenching, then by a sub-zero treatment at −60° C. and thereafter by tempering at 200° C.

EXAMPLE 7

The material used was SUJ2 as in Comparative Example 2. Heating at 845° C. for hardening was followed by oil quenching, then by a sub-zero treatment at −196° C. and thereafter by tempering at 200° C.

TABLE 4

Specimen	Material	Heat treatment	Residual austenite content (%)
Comp. Ex. 2	SUJ2	Standard hardening Tempering	11-14
Ex. 5	SUJ2	Standard hardening Tempering at 350° C.	Up to 3
Ex. 6	SUJ2	Standard hardening Sub-zero at −60° C. Tempering	9.7
Ex. 7	SUJ2	Standard hardening Sub-zero at −196° C. Tempering	5.9

The residual austenite content was determined by X-ray diffractiometry over the depth of 0.2 mm from the bearing raceway radially outward thereof. The bearing on the pulley side was of the size being No. 6302 (42 mm in outside diameter), and the bearing on the rear side was of the size bearing No. 6002 (32 mm in outside diameter).

Each pair of specimens was incorporated into an alternator and subjected to a high-speed high-tension test under the following conditions.

TABLE 5

Specimen	Duration of rotation until failure
Comp. Ex. 2	980 to 1260 horus, n = 10
Example 5	No failure for 2500 hours (thereafter discontinued) n = 5
Example 6	No failure for 2500 hours (thereafter discontinued) n = 5
Example 7	No failure for 2500 hours (thereafter discontinued) n = 5

A failure occurred only in Comparative Example 2. More specifically, the failure was seizure involving carbonization of the grease and marked discoloration of the inner and outer rings and the balls, and the retainer was broken to lock the rotatable ring. The bearing on the pulley side only failed because this bearing, which is close to the pulley, is subjected to a greater momental load and therefore heated to a higher temperature than the other bearing on the rear side.

Although no failure occurred in Examples 5 to 7, the grease was checked for oxidation deterioration by infrared spectroscopic analysis, which revealed almost no deterioration in Examples 5 and 7 but deterioration proceeding in Example 6 only.

In Comparative Example 2, the temperature of the inner and outer rings was measured under the testing conditions to find that the outer ring was 8 to 12° C. higher than the inner ring in temperature. This indicates the following. The inner ring is connected to the rotor, which is driven at a higher speed than conventionally and is therefore fully self-cooled by a fan effect to lower the temperature of the inner ring to a level lower than in the prior art, whereas the outer ring is mounted on the frames having attached thereto the stator which evolves a larger amount of heat due to a higher output, with the result that a larger amount of heat is transferred from the stator to the outer ring to result in a higher temperature than conventionally.

For illustrative purposes, FIG. 6 shows the result obtained by measuring variations in the vibration level with the lapse of testing time by a vibration acceleration sensor attached to the frame. Although the specimens tested were found free of the failure that the rotor interferes with the stator to lock the rotatable ring, Comparative Example 2 exhibited a higher vibration level. Presumably, this indicates that the higher residual austenite content leads to greater plastic deformation.

Thus, when incorporating the bearings of Examples 5 to 7 containing a reduced amount of residual austenite, the alternator can be adapted for a high-speed operation under increased tension.

Incidentally, the conventional bearings for use in precision machines or devices or the like include those subjected to the sub-zero treatment in order to inhibit the dimensional variations due to the decomposition of austenite. According to the present invention, on the other band, attention is directed not to such dimensional stability but to the characteristics of residual austenite per se to provide the combination of an alternator and a bearing which contains a reduced amount of residual austenite so as to exhibit outstanding performance in an environment involving vibration or impact. Consequently, the invention achieves the entirely novel effect of making the alternator smaller in size, lower in weight and higher in output.

Carburized materials such as SAE5120 are usable for the present bearing to conduct the sub-zero treatment after carburization hardening. In this case, unlike the use of SUJ2, additional compressive residual stress is available which is advantageous to fatigue life. Accordingly, such materials are useful for assuring higher tension for rotation at a further increased speed as will be apparent from the result of Examples 3 and 4 listed in Table 2 and achieved with the ball bearings.

What is claimed is:

1. An alternator for vehicles comprising a rotary shaft of a rotor which is rotably supported by a pair of bearings,..each comprising a fixed ring and a rotary ring, on a frame having a stator, and a drive pulley which is mounted on one end of the rotary shaft projecting outward from the frame, wherein the alternator comprises at least the bearing directed toward the pulley comprising a fixed ring comprising a steel containing up to about 10% of residual austenite.

2. An alternator as defined in claim 1 wherein said steel containing limited proportion of austenite has been made by subjecting steel having a higher austenite content to a sub-zero treatment.

3. An alternator as defined in claim 1 wherein said steel containing limited proportion of austenite has been made by subjecting steel having a higher austenite content to tempering at a temperature of 250° to 380° C.

4. An alternator as defined in claim 1 wherein said steel containing limited proportion of austenite has been made by subjecting steel having a higher austenite content to a sub-zero treatment and a subsequent tempering treatment at a temperature of 170° to 230° C.

5. An alternator as defined in claim 1 wherein said steel has been subjected to carburization hardening.

6. An alternator as defined in claim 1 wherein the amount of residual austenite is up to 6%.

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